

## SECTION 16960

### COORDINATED POWER SYSTEM PROTECTION

#### PART 1 GENERAL

##### 1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

#### INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	(2007; Errata 2006; Errata 2007; INT 44-56 2007; INT 47, 49, 50, 52-56 2008; INT 57, 58, 51, 48 2009) National Electrical Safety Code
IEEE Std 242	(2001; Errata 2003) Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems - Buff Book
IEEE Std 399	(1997) Recommended Practice for Power Systems Analysis - Brown Book

#### INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2009) Acceptance Testing Specifications
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#### NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2008; AMD 1 2008) National Electrical Code - 2008 Edition
NFPA 70E	(2008) Standard for Electrical Safety in the Workplace

##### 1.2 SYSTEM DESCRIPTION

The power system analysis to be performed by the Contractor consists of:  
Drawing 79K38550, all new equipment installed downstream of Switch Station 1001.

The Government will provide:

1. Short circuit data for all 13.8 kV connections to low voltage equipment.

2. Protective relay settings, arc-flash data, and short circuit data for Switch Station 1001. The Contractor shall provide arc-flash labels based on the Government supplied data.

### 1.3 SUBMITTALS

Submit for Government approval the following in accordance with Section 01330  
SUBMITTAL PROCEDURES:

#### SD-03 Product Data

##### Fault Current and Arc Flash Analysis Protective Device Coordination Study

The study along with protective device equipment submittals. No time extensions or similar contract modifications will be granted for work arising out of the requirements for this study. Approval of protective devices proposed will be based on recommendations of this study. The Government shall not be held responsible for any changes to equipment, device ratings, settings, or additional labor for installation of equipment or devices ordered and/or procured prior to approval of the study.

Review and final submittals shall consist of 5 bound copies and a PDF file submitted on Compact Disc (CD). Also provide on a final submittal CD, all power system analysis software data files necessary to restore and edit the model.

##### Equipment

Data consisting of manufacturer's time-current characteristic curves for individual protective devices, recommended settings of adjustable protective devices, and recommended ratings of non-adjustable protective devices.

##### System Coordinator

Verification of experience and license number, of a State of Florida registered Professional Engineer with at least 3-years of current experience in the design of coordinated power system protection. Experience data shall include at least five references for work of a magnitude comparable to this contract, including points of contact, addresses and telephone numbers. This engineer must perform items required by this section to be performed by a Florida registered Professional Engineer.

##### Protective Relays

Data including calibration and testing procedures and instructions pertaining to the frequency of calibration, inspection, adjustment, cleaning, and lubrication.

#### Installation

Procedures including diagrams, instructions, and precautions required to properly install, adjust, calibrate, and test the devices and equipment.

### 1.4 QUALITY CONTROL

The completed fault current and arc flash analysis and protective device coordination study documents shall be reviewed at a KSC location and implemented as follows:

90 percent document and review meeting at KSC: Study is complete except for disposition of Government comments.

100 percent document: Incorporates approved Government comments and submitted in accordance with Section 01330 SUBMITTAL PROCEDURES. Setting sheets from this document are to be used to implement protective device settings.

Installation field change document and review meeting at KSC: Required if setting changes in protective devices are required due to discrepancies between the 100 percent setting sheet documents and the available setting selections on the protective device. All applicable portions of the fault current and arc flash analysis and protective device coordination study document shall be changed and annotated to reflect the impacts of the setting changes.

As-Built document: Incorporates as-installed protective device settings Government comments and submitted in accordance with Section 01330 SUBMITTAL PROCEDURES.

## PART 2 PRODUCTS

### 2.1 Arc-Flash Labels:

Provide detailed arc flash warning labels for all electrical equipment as required by NFPA 70 and NFPA 70E, including, medium voltage switches, transformers, switchgear main breakers, switchgear bus-tie breaker, switchgear feeder breakers, switchgear cable compartments, switchboards, panelboards, motor control centers, enclosed breakers, safety switches automatic transfer switches, motor starters, control panels, and other equipment modified or installed by the project that is likely to require examination, adjustment, servicing, or maintenance while energized.

- a. Label format is to be NFPA 70E detailed format type and samples will be provided at the time of award. Format includes different colors and formatting per NEMA Z535.1 for different hazard levels and the following information:
  - i.) Flash hazard boundary
  - ii.) Incident energy
  - iii.) Hazard Category and PPE
  - iv.) Shock Voltage
  - v.) Minimum insulated glove rating
  - vi.) Limited approach boundary distance
  - vii.) Restricted approach boundary distance
  - viii.) Prohibited approach boundary distance
- b. The arc flash label content shall be based on the operational scenario, fault location, and fault type (arcing or bolted) that results in the highest incident energy.

## 2.14 COORDINATED POWER SYSTEM PROTECTION

Analyses shall be prepared to demonstrate that the equipment selected and system constructed meet the contract requirements for ratings, coordination, and protection. They shall include a fault current and arc flash analysis, and a protective device coordination study. The studies shall be performed by a registered professional engineer with demonstrated experience in power system coordination in the last 3-years. Provide a list of references complete with points of contact, addresses and telephone numbers. The selection of the engineer is subject to the approval of the Contracting Officer.

Perform short circuit studies, coordination studies, and arc-flash hazard analysis in accordance with NETA ATS and as specified herein.

### 2.14.1 Scope of Analyses

The fault current and arc flash analysis, and protective device coordination study shall begin at: 13.8 kV Switch Station 1001 (Switch Station 1001 data to be provided by the Government) and extend down to all electrical equipment shown on Drawings indicated in Paragraph 1.2 SYSTEM DESCRIPTION.

### 2.14.2 Determination of Facts

The time-current characteristics, features, and nameplate data for each existing protective device shall be determined and documented. Coordinate with the Government Lead Electrical Design Engineer for fault current availability at the site.

Review protective device submittals, perform field surveys, make notations on submittals, and coordinate with equipment vendor as required to obtain all new device data necessary for the coordination study.

### 2.14.3 Single Line Diagram

A single line diagram shall be prepared to show the electrical system buses, devices, transformation points, and all sources of fault current (including generator and motor contributions). A fault-impedance diagram or a computer analysis diagram may be provided. Each bus, device or transformation point shall have a unique identifier. If a fault-impedance diagram is provided, impedance data shall be shown. Location of switches, breakers, and circuit interrupting devices shall be shown on the diagram together with available fault data, and the device interrupting rating. Include on the single line names of equipment as indicated on the drawings or provide a table cross-referencing node numbers to equipment names on the drawings.

### 2.14.4 Fault Current Analysis

#### 2.14.4.1 Method

The fault current analysis shall be performed in accordance with methods described in IEEE Std 242, and IEEE Std 399.

Analysis shall utilize specialized computer aided engineering software designed for the purpose including the following capabilities.

- a. Short circuit analysis with asymmetrical and symmetrical values for different fault times.
- b. Time current curve plotting.
- c. Arc-flash energy calculation for both arcing and bolted fault current levels.

#### 2.14.4.2 Data

Actual data shall be utilized in fault calculations. Bus characteristics and transformer impedance shall be those proposed. Data shall be documented in the report.

#### 2.14.4.3 Fault Current Availability

Balanced three-phase fault, bolted line-to-line fault, and line-to-ground fault current values shall be provided at each voltage transformation point and at each power distribution bus. The maximum and minimum values of fault available at each location shall be shown in tabular form on the diagram or in the report.

#### 2.14.5 Coordination Study

The study shall demonstrate that the maximum possible degree of selectivity has been obtained between devices specified, consistent with protection of equipment and conductors from damage from overloads and fault conditions. The study shall include a description of the coordination of the protective devices in this project. A written narrative shall be provided describing: which devices may operate in the event of a fault at each bus; the logic used to arrive at device ratings and settings; situations where system coordination is not achievable due to device limitations (an analysis of any device curves which overlap); coordination between upstream and downstream devices; and relay settings. Recommendations to improve or enhance system reliability, and detail where such changes would involve additions or modifications to the contract and cost damages (addition or reduction) shall be provided. Composite coordination plots shall be provided on log-log graph paper.

#### 2.14.6 Study report

- a. The report shall include a cover sheet and table of contents. Separate sections with all applicable content shall be provided for all operating scenarios.
- b. The report shall include a narrative describing: the analyses performed; the bases and methods used; and the desired method of coordinated protection of the power system.
- c. The report shall include single-line line diagram(s); reference 2.14.3, Single Line Diagram.
- d. The study shall include descriptive and technical data for existing devices and new protective devices proposed. The data shall include manufacturers published data, nameplate data, time-current curves, and definition of the fixed or adjustable features of the existing or new protective devices.
- e. The report shall document utility company data including system voltages, fault MVA, and system X/R ratio.
- f. The report shall contain fully coordinated composite time-current characteristics curves for each bus in the system, as required to substantiate all protective devices settings and to ensure coordinated power system protection between protective devices or equipment. Provide separate curves for phase and ground fault currents. The report shall include recommended ratings and settings of all protective devices in tabulated form.
- g. The report shall provide the calculation performed for the analyses, including computer analysis programs utilized. The name of the software package, developer, and version number shall be provided. For all nodes, include phase fault short circuit levels and X/R ratios, ground fault short circuit levels

and X/R ratios, load flow levels, arc-flash energy (for both bolted and arcing short circuit current levels), and motor starting study results.

- h. The report shall include protective device setting sheets including recommended changes to existing protective device settings and settings for all new protective devices including but not limited to protective relays, breaker trip units, molded case breakers/motor circuit protectors with adjustable instantaneous trip settings, motor starter overloads. All information to field install the settings, including settings or features not used or turned off, shall be provided. Setting sheets shall be separate pages, suitable for use by installing technicians, and not include other report analysis and data.
- i. The report shall include tabulated arc-flash label data for all equipment requiring an arc-flash warning label and all modified equipment also requiring an arc-flash label.

## PART 3 EXECUTION

### 3.2 INSTALLATION

Install protective device settings in accordance with the manufacturer's published instructions and in accordance with the protective device coordination study protective device setting sheets.

Affix detailed arc flash warning labels to all electrical equipment as required by NFPA 70 and NFPA 70E.

### 3.3 FIELD TESTING

#### 3.3.1 General

Section 16960 APPARATUS, COORDINATION, INSPECTION AND TESTING, applies to this section, with the additions and modifications specified herein. Breaker settings shall be installed prior to any primary or secondary current injection testing.

#### 3.3.2 Safety

Provide and use safety devices such as arc flash personal protective equipment, electrically insulating rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. Replace any devices or equipment which are damaged due to improper test procedures or handling.

#### 3.3.3 Molded-Case Circuit Breakers, Motor Circuit Protectors, and Motor Starters.

Devices shall be visually inspected. Current ratings shall be verified and adjustable settings incorporated in accordance with the coordination study.

### 3.3.4 Power Circuit Breakers

#### 3.3.4.1 General

Visually inspect circuit breaker and implement settings in accordance with the coordination study.

### 3.3.5 Protective Relays

Protective relays shall be visually inspected. Relay settings shall be implemented in accordance with the coordination study.

-- End of Section --